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The Tick Vector of Relapsing Fever

W. B. Herms, D.Sc. and C. M. Wheeler, Ph.D.*

Evidence accumulated in the field and in the laboratory has definitely established the argasine tick, *Ornithodoros hermsi* Wheeler, as the chief if not the only arthropod vector of relapsing fever in California.

This tick has been taken on numerous occasions in nesting material of small rodents found in hollow logs and between the walls of cottages in the two principal relapsing fever areas of the state. This new species of tick appears to be a parasite of small mammals, particularly chipmunks, but will feed readily on various species including mice, monkeys, and humans if the opportunity is afforded.

DISTRIBUTION

Ornithodoros hermsi is apparently widely distributed in the Sierra Nevada and San Bernardino ranges in California at elevations of 5000 to 8000 feet. Specimens have been taken abundantly from two areas, namely, Big Bear Lake in San Bernardino County and Lake Tahoe in El Dorado County.

LIFE CYCLE OF THE TICK

The tiny eggs of this tick are light amber colored when first deposited. They are nearly spherical in outline (493.7 microns by 470.25 microns) and are deposited in loosely agglutinated masses of from 12 to 140. One female deposited 232 eggs in four batches over a period of four months.

The incubation period ranges from 15 to 21 days at a temperature of approximately 75 degrees F. and 90 per cent humidity. In this species, as well as many other species of *Ornithodoros,* there appears to be a marked decrease in the numbers and in the per cent of fertility of the eggs with each successive batch produced by a given female tick. The percentage of larvae hatching from the successive batches ranges from 95 per cent in the first to less than 50 per cent in later hatches.

The newly hatched very minute larvae are nearly spherical, six legged and are a light buff color. The first molt usually occurs within the egg; the second molt occurs shortly after hatching and the young ticks (seed ticks) are ready to feed in two or three days. The larvae, when fully engorged, increase as much as three times in size and acquire a bright red color due to the imbibed blood. In this condition these tiny ticks have been described as a "strawberry seed insect" by some of the people living in the relapsing fever areas. Fifteen days after feeding the larvae molt, giving rise to the first nymphal stage when the fourth pair of legs appears. The first stage nymphs now feed and in from 11-15 days thereafter the second nymphal stage comes into existence; then follows another feeding period with another molt and the appearance of the third stage nymphs. The adult stage is reached after the next feeding and another molt.

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Five molts usually occurring during the life cycle from larvae to sexually mature adults although in a few instances six molts have been observed. When males and females are placed together fecundation may take place within a few days and eggs are deposited shortly thereafter.

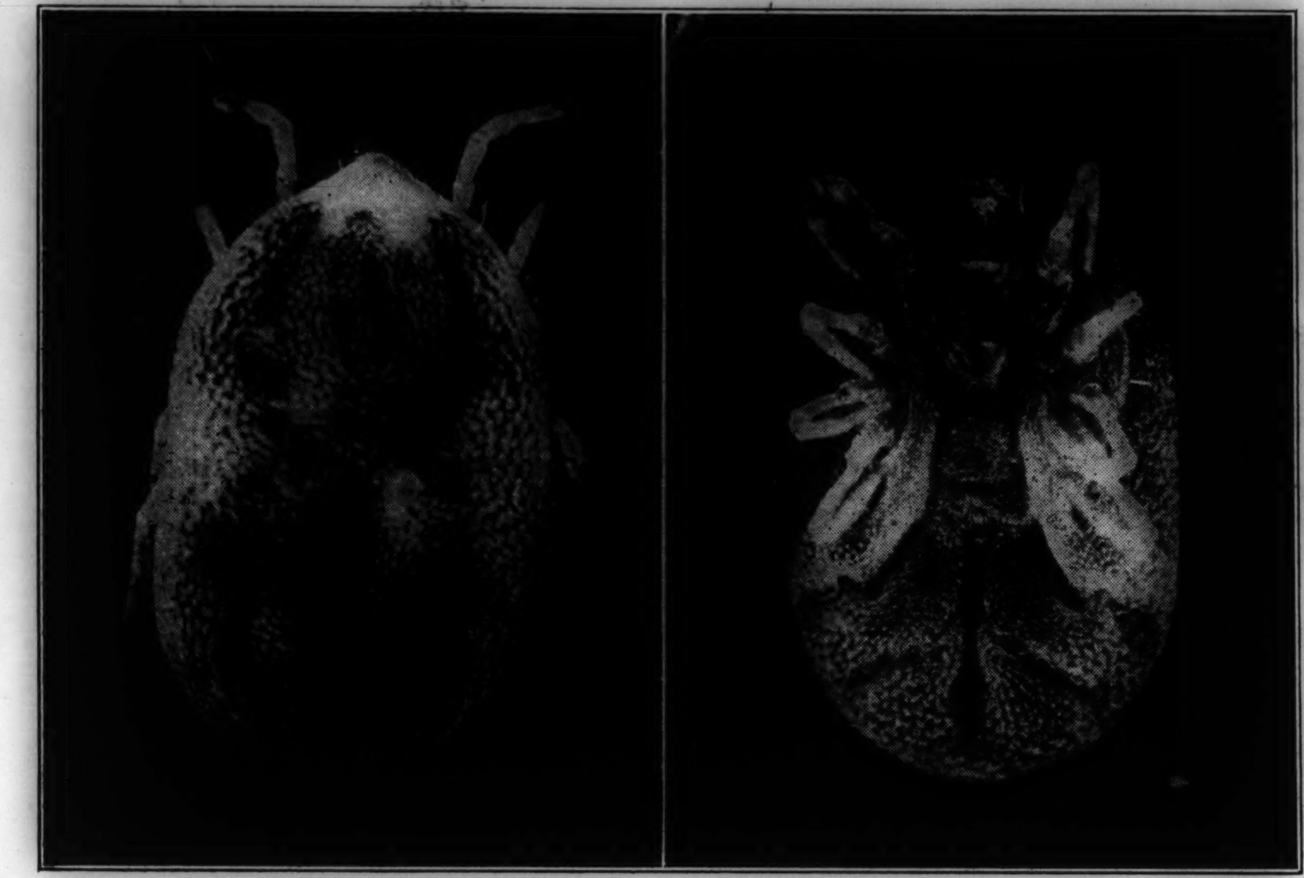

FIG. II. *Ornithodoros hermsi* Wheeler, vector of relapsing fever in California. Mature female tick, dorsal view left, ventral view right. Measures about 5 mm. in length by 3.5 mm. in width.

DESCRIPTION OF MATURE TICK

The mature tick is rather small as compared with the majority of species of other *Ornithodoros* occurring in California. The female measures from 5 to 6 mm. in length by 3 to 4 mm. in width. (Figs. II, III, IV.) The males resemble the females in general appearance but are slightly smaller, measuring approximately 3 x 2 mm. These ticks have been described as "ovoid, conically pointed anteriorly, anterior dorsal portion of the hood visible from above, broadly rounded posteriorly; unengorged specimens a light sandy color with the black of the intestinal diverticulae visible through the integument of the dorsal surface; freshly engorged specimens a dull, deep garnet shade with a greyish sheen over body, anterior conical point whitish. The color changes to a greyish blue a few days after feeding. Legs and hood pale yellow. In newly molted forms the body and legs lighter but gradually assuming the light sandy appearance and the legs darkening correspondingly."

Ornithodoros hermsi Wheeler "differs from *Ornithodoros talaje* (Guer.-Men.) a close relative in (a) the absence of large discs on the dorsum, (b) the characteristic sculpturing of the integument, (c) microscopical differences in the structure of the integument, (d) arrangement of the dentition of the hypostome, (e) the absence of lateral flap-like borders on the margins of the capitulum, (f) the shape of the cheliceral teeth, (g) the shape of the anal grooves and (h) the tarsi bearing diagnostic protuberances. This new species differs from *Ornithodoros venesuelensis* (Brumph) in (a) the sculpturing of the dorsum, (b) the protuberances of the tarsi, (c) shape and position of anal grooves, and (d) the dentition of the hypostome. This new tick differs from *Ornithodoros turicata* (Duges) in (a) the absence of clubbed hairs between the mammillae, (b) the arrangement and number of teeth on the hypostome, (c) the decidedly smaller hypostome, (d) the arrangement and number of protuberances on tarsi I and IV in particular and (e) the smaller size of the adults."

FEEDING HABITS

All of the active stages of *Ornithodoros hermsi* are capable of rapid engorgement. The larvae attach almost immediately when placed upon the skin of a laboratory animal and reach repletion in from 12–15 minutes. Occasionally some larvae will remain attached for a period of thirty minutes or more. The nymphal instars may reach complete engorgement in approximately thirty minutes while the adults feed from fifteen minutes to an hour, the average time being about the same as that of the nymphs, namely about thirty minutes. As soon as the ticks have engorged they detach, drop from the host and seek a place of concealment.

The coxal fluid of this species of tick crystallizes almost immediately on coming into contact with the air so that there is no possibility of this fluid wetting the wound made by the mouth parts of the feeding tick. In many species of ticks of this genus a copious amount of coxal fluid flows from the coxal glands at the time the tick reaches a state of complete engorgement. This material is believed by many workers to be one of the chief means of transmission of the spirochaetes of relapsing fever. Our tests indicate that the coxal fluid of *Ornithodoros hermsi* plays no part in the transmission of the spirochaetes. Tests in which white mice were inoculated with dissolved crystals of the coxal fluid removed from the ventral surface of *Ornithodoros hermsi* failed to produce infections in these animals. Likewise fecal material removed by means of a capillary tube directly from the anal opening of an infective female tick failed to produce the disease when injected intraperitoneally into white mice.

LONGEVITY

Ornithodoros hermsi may undergo fairly long periods of fasting. Larvae may live without food from 30 to 95 days; the first stage nymphs 2 to 154 days; second stage nymphs 25 to 79 days; third stage nymphs 1 to 109 days, and the adults well over 7 months. Adult ticks have been kept alive in pill boxes with occasional feedings for a period of over 20 months. Doubtless they may survive a period of at least two years as adults under natural conditions.

TRANSMISSION OF RELAPSING FEVER SPIROCHAETES BY ORNITHODOROS HERMSI

The first evidence incriminating this species of ticks as a vector of relapsing fever was secured when six late stage nymphal ticks taken in nature were permitted to engorge on a macacarus monkey. This animal developed characteristic symptoms of the disease 16 days later and spirochaetes were demonstrated in the blood stream. Infection was produced directly through the bites of these ticks as no coxal fluid or fecal material was observed on the skin of the monkey or on the ventral surface of the ticks.

The second series of transmission experiments involved the use of white mice as laboratory animals. When infected ticks, in either of the three nymphal instars or as adults, were allowed to engorge on blood of white mice, these animals developed the infection usually on the fifth day after being bitten by the ticks. Occasionally certain of the mice develop symptoms on the 4th day while in others spirochaetes were not found until the 7th day.

The results of the transmission experiments indicate that at least 20.8 per cent of the ticks taken in nature may be infective. Also that 35 per cent of noninfective ticks when allowed to feed on diseased animals are able to acquire the spirochaetes and to transmit them to normal animals at the next feeding. Once the ticks acquire the infection, they tend to remain infective throughout their entire life and may produce repeated infections in susceptible animals.

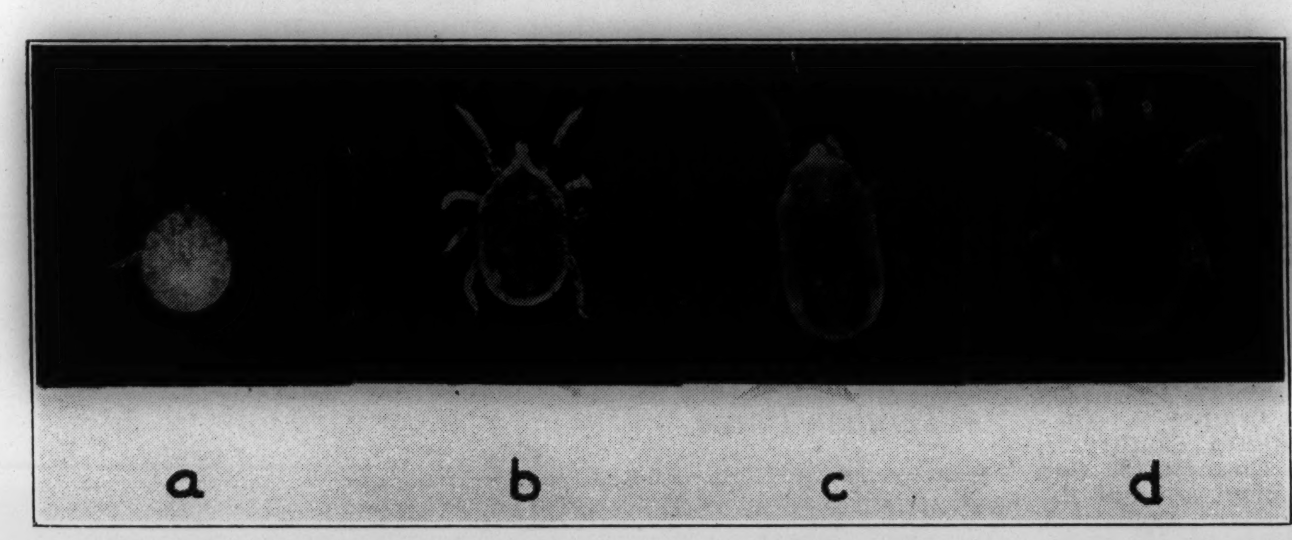

FIG. IV. Showing immature stages of *Ornithodoros hermsi*, (a) larva, (b) first nymphal stage, (c) second nymphal stage, (d) third nymphal stage. Enlarged about ten times.

That the spirochaetes may be transmitted from infected female to offspring through the egg has been demonstrated in ticks originating in the two principal relapsing fever areas of the state. Less than 2 per cent of the progeny resulting from an infective female tick have been shown to be positive by feeding tests on normal white mice. This small percentage apparently is sufficient to prevent a "racial suicide" among the spirochaetes. Experiments have also shown that the progeny from an apparently noninfective female tick may produce infective progeny and that the progeny from an infective female tick may produce noninfective progeny.

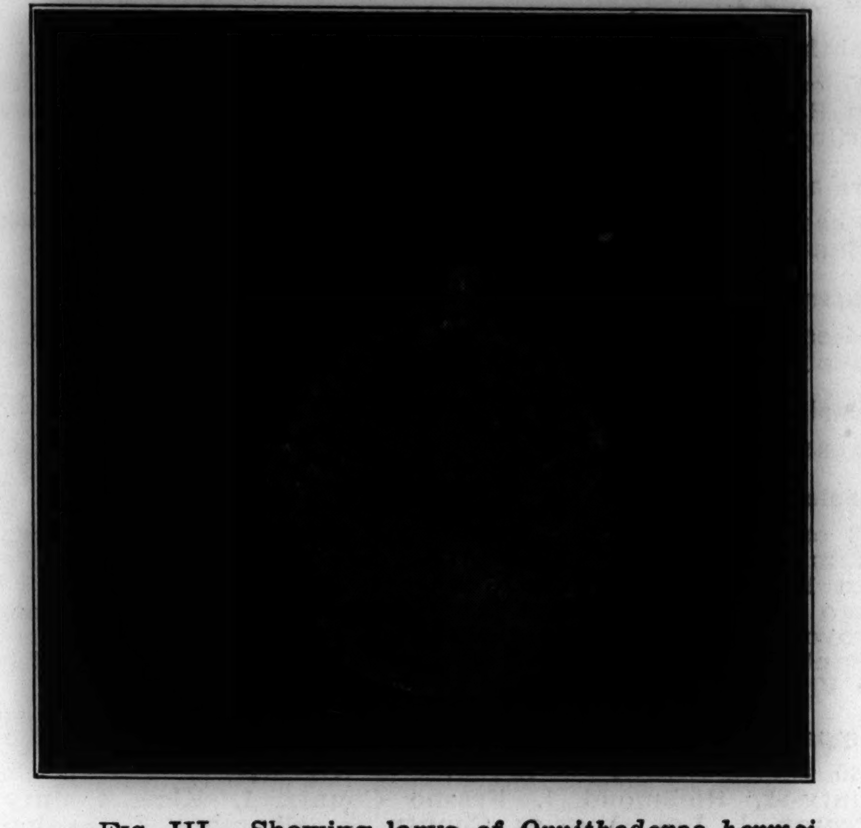

FIG. III. Showing larva of *Ornithodoros hermsi* greatly enlarged. Natural size of the larva is slightly less than one millimeter when not engorged with blood. Note that larva has only three pairs of legs.

Three other species of *Ornithodoros* occurring in the valleys and in the coast ranges of California failed to transmit the disease from infected mice to normal mice.

The "bite" of *Ornithodoros hermsi* is apparently quite benign, at least in the larval stage, and is in accord with the general theory that anthropods with a benign bite are the most efficient vectors of disease organisms. Larval ticks produce no sensation of pain when permitted to feed on the arms of volunteers. Mice and monkeys show but slight signs of discomfort either during the time the ticks are feeding or after the ticks have dropped although a small local hemorrhagic area forms at the point of insertion shortly after the tick has attached.

He sleeps well who knows not that he sleeps ill.—Maxim.

MORBIDITY

Complete Reports for Following Diseases for Week Ending August 29, 1936

Chickenpox

22 cases: Alameda 1, Oakland 3, Glendale 1, Long Beach 1, Los Angeles 4, Madera County 1, Riverside County 1, Coronado 1, San Diego 2, San Francisco 1, Burlingame 1, Santa Barbara County 1, Santa Clara County 1, Santa Cruz 1, Santa Rosa 1, Red Bluff 1.

Diphtheria

25 cases: Oakland 2, Los Angeles County 4, Los Angeles 9, San Bernardino 1, Oceanside 1, San Diego 1, San Francisco 2, Burlingame 1, San Mateo 2, San Jose 1, Santa Rosa 1.

German Measles

8 cases: Berkeley 3, Pomona 1, Santa Ana 1, Lodi 1, Stockton 1, Santa Clara County 1.

Influenza

14 cases: Oakland 1, Huntington Park 1, Los Angeles 10, San Francisco 1, Mountain View 1.

Malaria

3 cases: Madera County 1, Yuba County 1, California 1*.

Measles

43 cases: Oakland 1, Kern County 4, Los Angeles County 2, Alhambra 1, Beverly Hills 1, Glendale 1, Los Angeles 6, Pasadena 1, Redondo 1, Napa County 1, San Diego County 1, San Diego 5, San Francisco 1, Lodi 1, San Luis Obispo County 6, Arroyo Grande 1, San Luis Obispo 1, Burlingame 1, Hillsborough 1, Santa Clara County 1, Palo Alto 1, Santa Clara 1, Fairfield 1, Rio Vista 1, Ventura County 1.

Mumps

130 cases: Albany 1, Berkeley 4, Oakland 3, Contra Costa County 2, Richmond 1, Fresno County 1, Kern County 6, Corcoran 1, Los Angeles County 6, Alhambra 2, Avalon 1, Beverly Hills 2, Glendale 1, Long Beach 6, Los Angeles 21, Montebello 1, Pasadena 7, Pomona 2, South Pasadena 1, Whittier 1, South Gate 1, Pacific Grove 1, Orange County 7, Anaheim 1, Brea 1, Orange 3, Santa Ana 8, Riverside County 1, Corona 1, Sacramento 1, San Bernardino 1, San Diego County 5, Coronado 2, San Diego 13, San Francisco 1, Lodi 2, Stockton 1, Santa Barbara County 1, Santa Barbara 1, Santa Clara 1, Vallejo 1, Tulare County 1, Lindsay 1, Ventura County 1, Woodland 2, Yuba County 1.

Pneumonia (Lobar)

21 cases: Oakland 1, Colusa 1, Richmond 1, Eureka 2, Los Angeles County 2, Los Angeles 7, Monterey Park 1, Anaheim 1, Sacramento 1, San Bernardino 1, San Francisco 1, San Jose 2.

Scarlet Fever

66 cases: Alameda County 1, Albany 1, Amador County 1, Chico 1, Contra Costa County 3, Fresno County 1, Fresno 5, Kern County 1, Kings County 4, Los Angeles County 1, Avalon 1, Los Angeles 7, Pasadena 3, Santa Monica 1, Lynwood 1, Marin County 1, Sacramento 6, San Diego County 2, San Diego 3, San Francisco 12, Paso Robles 1, San Mateo County 1, San Bruno 1, Santa Clara County 3, Palo Alto 1, Petaluma 1, Ventura County 1, Yuba County 1.

Typhoid Fever

15 cases: Butte County 1, Martinez 3, Lake County 1, Los Angeles 2, Yosemite 1, Grass Valley 1, Sacramento County 1, San Bernardino 1, San Diego 2, San Luis Obispo County 1, Yolo County 1.

Whooping Cough

136 cases: Berkeley 3, Oakland 3, El Cerrito 2, Fresno County 1, Los Angeles County 13, Glendale 3, Los Angeles 37, Pasadena 2, Pomona 1, South Gate 1, Salinas 1, Orange County 2, Anaheim 1, Placer County 2, Corona 1, Sacramento County 1, Sacramento 6, San Bernardino 2, San Diego County 12, San Diego 10, San Francisco 10, San Joaquin County 4, Lodi 6, San Mateo County 2, Santa Barbara 1, Santa Clara County 3, Gilroy 2, Santa Cruz 3, Lindsay 1.

Meningitis (Epidemic)

1 case: Calaveras County.

Dysentery (Amoebic)

3 cases: Fresno County 1, San Francisco 2.

Dysentery (Bacillary)

2 cases: Los Angeles 1, Sacramento 1.

Pellagra

3 cases: Los Angeles.

Poliomyelitis

12 cases: Los Angeles County 1, Los Angeles 2, Montebello 1, San Gabriel 1, Whittier 1, Santa Ana 1, Chula Vista 1, San Luis Obispo 1, Tulare County 2, Ventura County 1.

Tetanus

1 case: Los Angeles County.

Encephalitis (Epidemic)

3 cases: Oakland 1, Fresno County 1, San Jose 1.

Paratyphoid Fever

4 cases: Alameda 1, Los Angeles 1, Auburn 1, San Rafael 1.

Undulant Fever

3 cases: Los Angeles County 1, San Francisco 1, Red Bluff 1.

Septic Sore Throat

3 cases: Oakland 2, Los Gatos 1.

Tularemia

1 case: California*.

Rabies (Animal)

9 cases: Los Angeles County 3, Glendale 1, Los Angeles 2, Redondo 1, Torrance 1, Stockton 1.

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* Cases charged to "California" represent patients ill before entering the state or those who contracted their illness traveling about the state throughout the incubation period of the disease. These cases are not chargeable to any one locality.

Eat less; chew more.
Waste less; give more.
Ride less; walk more.
Go less; sleep more.
Talk less; listen more.
Worry less; work more.
Idle less; think more.
Preach less; practice more.
Clothes less; bathe more.
Scold less; laugh more.

"To make the most of dull hours; to make the best of dull people; to like a poor jest better than none; to wear the threadbare coat like a gentleman; to be out-voted with a smile; to hitch your wagon to the old horse if no star is handy—that is wholesome philosophy."—Bliss Perry.

The sublime and the ridiculous are often so nearly related that it is difficult to class them separately. One step above the sublime makes the ridiculous and one step above the ridiculous makes the sublime again. —Thomas Paine.

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